CLAIMS

1. A device for ultra-high frequency hydrometric measurements comprising:

- electric means capable of generating sine wave trains at frequencies assuming several values in arithmetic progression between a few MHz and a few GHz,

- at least one ultra-high frequency cable along which at least two measuring stations (4) are found, each measuring station having a separator device capable of only sampling from the incident wave a portion with sufficient energy so that the measuring cell sends back an echo measurable by electronic read-out means, on the one hand, and a measuring cell (14) consisting of a ultra-high frequency line portion, on the other hand, the distal end of which is terminated by a short circuit, this line portion having an external wall either porous or provided with ports, and having its dielectric essentially consisting of a sample of homogeneous dielectric material for which permittivity is a monotonous function of the hydrometry in the relevant measurement domain,

- electronic read-out means with which, from signals having traveled through the ultra-high frequency cable, values of the real and imaginary parts of the permittivity may be determined, in order to determine the measurement of humidity and temperature by correlation with tables of values experimentally established beforehand by means of another hydrometric measurement method.

2. A device for hydrometric measurements, according to claim 1, wherein the electronic read-out means include means: for digitizing these signals, for filtering them in frequency, for calculating the complex reflection coefficient in the frequency domain, for performing a Fourier transform in order to calculate the complex reflection coefficient in the time domain, and then for determining the values of the real and imaginary parts of the permittivity.

3. The device for hydrometric measurements, according to any of claims 1 or 2, wherein the read-out means are located at the same end of the ultra-high frequency cable as the means for generating sine wave trains, and are connected to this ultra-high frequency cable by a directive coupler.

4. The device for hydrometric measurements, according to any of claims 1 or 3, wherein the ultra-high frequency cable is coaxial.

5. The device for hydrometric measurements, according to any of claims 1, 2 or 3, wherein the ultra-high frequency cable is shielded and bifilar.

6. The device for hydrometric measurements, according to any of claims 1 to 3, wherein the ultra-high frequency cable is unshielded and bifilar.

7. The device for hydrometric measurements, according to any of claims 1 to 6, wherein the

measuring cell is coaxial with the ultra-high frequency cable, and the latter has sudden narrowing at this cell.

8. The device for hydrometric measurements, according to claim 1 and to any of claims 3 to 5, wherein the device capable of only sampling from the incident wave, a portion having sufficient energy, is a power divider, and the measuring cell is placed in derivation relatively to the ultra-high frequency cable.

9. The device for hydrometric measurements, according to claim 1, wherein the external wall of the measuring cell is provided with slits directed along the wave propagation vector.

10. The device for hydrometric measurements, according to claim 1, wherein the external wall of the measuring cell is porous.

11. The device for hydrometric measurements, according to claims 1, 3 and 6 or to claims 1, 4 and 6, wherein the measuring cell includes a hollow cylinder-shaped cavity delimited by:

- an inner conducting cylindrical surface, also forming the shielding of the shrinked portion of the ultra-high frequency cable,
- an outer conducting cylindrical surface, electrically connected through its two ends to the

shielding of both ultra-high frequency cable sections which surround it,

- the distal portion of this cavity consisting of a conducting washer putting both cylindrical surfaces and the downstream portion of the ultra-high frequency cable into contact over 360°,

this cavity being filled at its end turned towards the generator, with a dielectric identical with the one of the cable, and occupying all the space between both cylinders over a length of a few millimeters, and being filled in the remaining portion with the homogeneous dielectric material sample, for which the permittivity is a monotonous function of the hydrometry.

12. The device for hydrometric measurements, according to claims 1, 5 and 6, wherein the measuring cell includes a hollow cylinder-shaped cavity delimited by:

- an inner conducting cylindrical surface, with a diameter less than the smallest diameter of the dielectric surrounding both conductors,

- an outer conducting cylindrical surface,

- the distal portion of this cavity consisting of a conducting washer putting both cylindrical surfaces into contact over 360°,

this cavity being filled at its end turned towards generator, with a dielectric identical with the one of the cable and occupying all the space between both cylinders over a length of a few millimeters, and being filled in the remaining portion with the

homogenous dielectric material sample for which permittivity is a monotonous function of the hydrometry.

13. The device for hydrometric measurements, according to any of claims 1 to 12, characterized in that one or more distal measuring cells sample a larger proportion of the incident microwave than the measuring cells closest to the source.

14. The device for hydrometric measurements, according to any of claims 1 to 12, characterized in that the dielectric of the ultra-high frequency cable and of the measuring cell have a continuous structure.

15. The device for hydrometric measurements, according to any of claims 1 to 13, including a first generator of sine wave trains, a multiplexing device successively switching these wave trains to one end of several ultra-high frequency cables, a vector voltmeter (43) connected to each of these ultra-high frequency cables and electronic means with which the complex reflection coefficient may be calculated in the frequency domain, a Fourier transform may be performed in order to calculate the complex reflection coefficient in the time domain, and then the values of the real and imaginary parts of the permittivity may be determined in order to determine the measurement of humidity and temperature by

correlation with tables of values experimentally established beforehand by means of another hydrometric measurement method.

16. The device for hydrometric measurements, according to claim 1, wherein the read-out means are located at the end of the ultra-high frequency cable, opposite to the one connected to the means for generating sine wave trains.

17. A hydrometric measurement assembly comprising at least one sensor according to any of claims 1 to 16, characterized in that the generator of sine wave trains and the electronic read-out means are formed with a network analyzer.

18. A hydrometric measurement assembly comprising at least one sensor according to any of claims 1 to 14, characterized in that the generator of sine wave trains is a frequency synthesizer, the electronic read-out means are formed with a vector voltmeter (43) associated with digital processing means.

DESCRIPTIVE ABSTRACT

A hydrometric sensor comprises a cable with a conducting core (1) surrounded by a dielectric sheath (2) which is interrupted at a succession of measurement stations (4), provided with a dielectric shield (6) with reduced section around which extends a volume filled with the test material. A portion of the signal enters this cavity, closed by a short circuited conducting ring (10) and which behaves as a resonant cavity in order to reflect a portion of the signal towards the source. The reflected signal is analyzed in order to infer from it the permittivity of the test material filling the cavity and therefore its humidity, as well as its temperature. A possible application is the monitoring of clays for confining used nuclear fuel.

Fig. 1.

Amended claims to file when entering the national phase

CLAIMS

1. A device for ultra-high frequency hydrometric measurements comprising:

- electric means capable of generating sine wave trains at frequencies assuming several values in arithmetic progression between a few MHz and a few GHz,

- at least one ultra-high frequency cable along which at least two measuring stations (4) are found, each measuring station having a separator device capable of only sampling from the incident wave a portion with sufficient energy so that the measuring cell sends back an echo measurable by electronic read-out means, on the one hand, and a measuring cell (14) consisting of a ultra-high frequency line portion, on the other hand, the distal end of which is terminated by a short circuit, this line portion having an external wall either porous or provided with ports, and having its dielectric essentially consisting of a sample of homogeneous dielectric material for which permittivity is a monotonous function of the hydrometry in the relevant measurement domain,

- electronic read-out means with which, from signals having traveled through the ultra-high frequency cable, values of the real and imaginary parts of the permittivity may be determined, in order to determine the measurement of humidity and temperature by correlation with tables of values experimentally established beforehand by means of another hydrometric measurement method.

Amended claims to file when entering the national phase

2. A device for hydrometric measurements, according to claim 1, wherein the electronic read-out means include means: for digitizing these signals, for filtering them in frequency, for calculating the complex reflection coefficient in the frequency domain, for performing a Fourier transform in order to calculate the complex reflection coefficient in the time domain, and then for determining the values of the real and imaginary parts of the permittivity.

3. The device for hydrometric measurements, according to claim 1, wherein the read-out means are located at the same end of the ultra-high frequency cable as the means for generating sine wave trains, and are connected to this ultra-high frequency cable by a directive coupler.

4. The device for hydrometric measurements, according to claim 1, wherein the ultra-high frequency cable is coaxial.

5. The device for hydrometric measurements, according to claim 1, wherein the ultra-high frequency cable is shielded and bifilar.

6. The device for hydrometric measurements, according to claim 1, wherein the ultra-high frequency cable is unshielded and bifilar.

7. The device for hydrometric measurements, according to claim 1, wherein the measuring cell is

coaxial with the ultra-high frequency cable, and the latter has sudden narrowing at this cell.

8. The device for hydrometric measurements, according to claim 3, wherein the device capable of only sampling from the incident wave, a portion having sufficient energy, is a power divider, and the measuring cell is placed in derivation relatively to the ultra-high frequency cable.

9. The device for hydrometric measurements according to claim 1, wherein the external wall of the measuring cell is provided with slits directed along the wave propagation vector.

10. The device for hydrometric measurements, according to claim 1, wherein the external wall of the measuring cell is porous.

11. The device for hydrometric measurements, according to claim 6, wherein the measuring cell includes a hollow cylinder-shaped cavity delimited by:

- an inner conducting cylindrical surface, also forming the shielding of the shrinked portion of the ultra-high frequency cable,
- an outer conducting cylindrical surface, electrically connected through its two ends to the shielding of both ultra-high frequency cable sections which surround it,

Amended claims to file when entering the national phase

- the distal portion of this cavity consisting of a conducting washer putting both cylindrical surfaces and the downstream portion of the ultra-high frequency cable into contact over 360°,

- this cavity being filled at its end turned towards the generator, with a dielectric identical with the one of the cable, and occupying all the space between both cylinders over a length of a few millimeters, and being filled in the remaining portion with the homogeneous dielectric material sample, for which the permittivity is a monotonous function of the hydrometry.

12. The device for hydrometric measurements, according to claim 6, wherein the ultra-high frequency cable is shielded and bifilar and the measuring cell includes a hollow cylinder-shaped cavity delimited by:

- an inner conducting cylindrical surface, with a diameter less than the smallest diameter of the dielectric surrounding both conductors,

- an outer conducting cylindrical surface,

- the distal portion of this cavity consisting of a conducting washer putting both cylindrical surfaces into contact over 360°,

this cavity being filled at its end turned towards generator, with a dielectric identical with the one of the cable and occupying all the space between both cylinders over a length of a few millimeters, and being filled in the remaining portion with the homogenous dielectric material sample for which

permittivity is a monotonous function of the hydrometry.

13. The device for hydrometric measurements, according to claim 1, characterized in that one or more distal measuring cells sample a larger proportion of the incident microwave than the measuring cells closest to the source.

14. The device for hydrometric measurements, according to claim 1, characterized in that the dielectric of the ultra-high frequency cable and of the measuring cell have a continuous structure.

15. The device for hydrometric measurements, according to claim 1, including a first generator of sine wave trains, a multiplexing device successively switching these wave trains to one end of several ultra-high frequency cables, a vector voltmeter (43) connected to each of these ultra-high frequency cables and electronic means with which the complex reflection coefficient may be calculated in the frequency domain, a Fourier transform may be performed in order to calculate the complex reflection coefficient in the time domain, and then the values of the real and imaginary parts of the permittivity may be determined in order to determine the measurement of humidity and temperature by correlation with tables of values experimentally established beforehand by means of another hydrometric measurement method.

Amended claims to file when entering the national phase

16. The device for hydrometric measurements, according to claim 1, wherein the read-out means are located at the end of the ultra-high frequency cable, opposite to the one connected to the means for generating sine wave trains.

17. A hydrometric measurement assembly comprising at least one sensor according to claim 1, characterized in that the generator of sine wave trains and the electronic read-out means are formed with a network analyzer.

18. A hydrometric measurement assembly comprising at least one sensor according to claim 1, characterized in that the generator of sine wave trains is a frequency synthesizer, the electronic read-out means are formed with a vector voltmeter (43) associated with digital processing means.